UNITED STATES DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN

WASHINGTON, D. C. 736 JULY 17, 1916

Contribution from the Bureau of Plant Industry, Wm. A. Taylor, Chief.

GINSENG DISEASES AND THEIR CONTROL.[1]

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IMPERIAL BUREAU OF MYCOLOGY
2 JUL 1921

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INTRODUCTION.[2]

The average yield of ginseng per acre in the United States is not more than one-sixth to one-third of what might reasonably be expected, the shortage being caused almost entirely by the numerous diseases which attack the crop. The time of appearance and the severity of these diseases in any given locality depend on climate, soil, and cultural relations, but so far as observed by the writers they are not confined to any particular region. Generally speaking, the same diseases are found in all ginseng-growing sections, from New York to the Pacific. The purpose of this bulletin is to bring to the

[1] For technical descriptions of the different diseases, see Bulletin No. 250 of the Bureau of Plant Industry, entitled "The Diseases of Ginseng and Their Control."

[2] This bulletin contains the results of cooperative work between the Bureau of Plant Industry, the New York (Cornell) Agricultural Experiment Station, the Wisconsin Agricultural Experiment Station, and the Michigan Agricultural Experiment Station.

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attention of ginseng growers the most recent information regarding the symptoms, cause, and control of the various diseases attacking the ginseng plant.

ALTERNARIA BLIGHT AND ROOT-ROT.

Alternaria blight has long been known as one of the most widespread of ginseng diseases, and the fact that the same disease may also affect the root, taking the form of a serious root rot, as recently discovered by one of the writers, shows that it is of even greater importance than hitherto supposed.

FIG. 1.—Leaves of ginseng affected with Alternaria blight.

Symptoms and cause.—During the spring the stems of some of the plants in gardens in which the disease existed the previous season show dark-brown spots or cankers of different sizes just above the surface of the ground. These spots, which are usually the first symptoms of the disease, enlarge and become velvety or fuzzy in appearance. A little later large dead spots in the leaves begin to appear. At first these have a water-soaked appearance, but gradually they become dry and papery in the center, with a darker, yellow-brown border (fig. 1). In later stages the leaflet may droop at the point of attachment to the leafstalk or where the leafstalk rises at the top of the stem. The affected part becomes coated with a velvety

brown dust at the point where it bends over. The seed heads also are often affected, and as a result the berries shell (fig. 2). In severe cases practically every plant in the bed becomes blighted (fig. 3).

FIG. 2.—Ginseng seed heads affected with Alternaria blight.

Affected roots rot very slowly. This rot has no odor. The lesions are dark brown to almost black, and the rotted roots never become soft (fig. 4). So far as known it would seem that only roots which have been injured in some way are attacked.

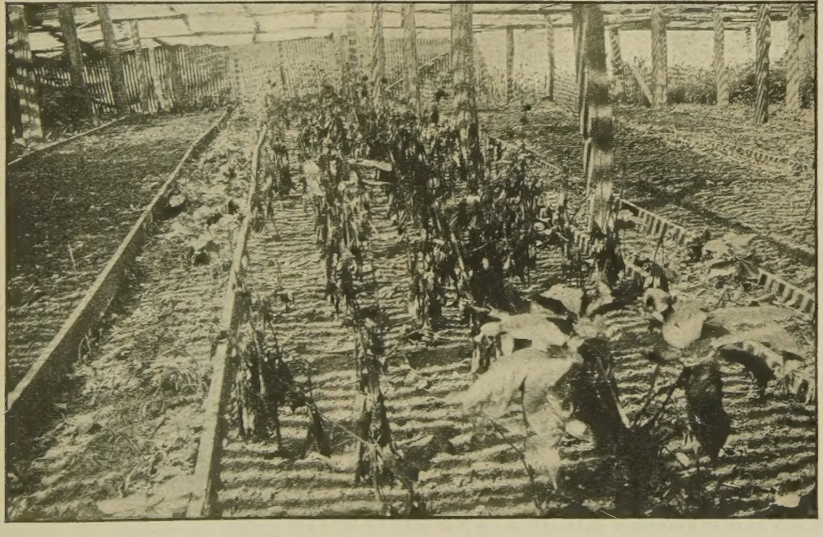

FIG. 3.—Bed of ginseng plants, showing the result of an epidemic caused by Alternaria blight.

The disease is caused by a fungus,[1] a minute moldlike growth. This lives and grows within the plant and pushes to the surface

[1] *Alternaria panax* Whetzel.

stalklike branches, on the ends of which the spores (microscopic seedlike bodies) are produced. The great number of these spores on the surface of affected stems gives the velvety brown or fuzzy appearance above mentioned (fig. 5). The spores are distributed by the wind and carried on the clothing from diseased to healthy gardens, and during rainy periods such spores as have lodged on the plants germinate and produce sprouts (germ tubes) which penetrate the tissues.

FIG. 4.—Ginseng root, showing Alternaria root-rot.

Control.—Sanitary measures, such as the removal and destruction of diseased tops, are of the greatest importance. After the tops die down the beds should be covered with a layer of dry straw and burned over, or if this can not be done they should be sprayed with a solution of copper sulphate, 1 pound to 5 gallons of water. Spraying the plants during the growing season is the best means of controlling the disease. The most satisfactory results were obtained from Bordeaux mixture, 3–3–50 (see p. 19), to which 2 pounds of lead arsenate for every 50 gallons of the mixture had been added (fig. 6). All susceptible parts of the plants should be kept well covered with the Bordeaux mixture. The first application should be made when the plants are pushing through the soil, and the treatment should be continued until they are up; the second when the leaves are fully expanded; and the third just after blossoming, in order to protect the seed heads.

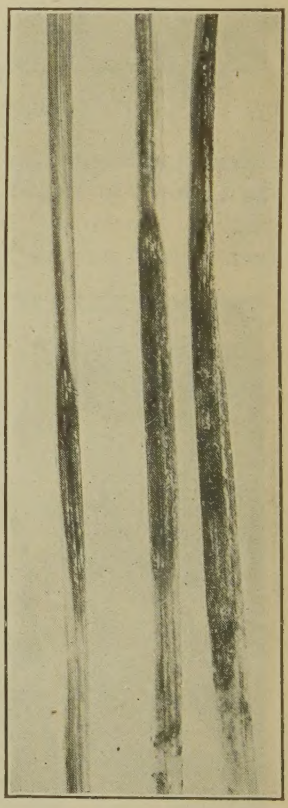

FIG. 5.—Stems of ginseng, showing a velvety brown or fuzzy appearance, caused by Alternaria blight.

PHYTOPHTHORA MILDEW AND ROOT-ROT.[1]

Phytophthora mildew and root-rot, which is also known as mildew, Japanese mildew,

[1] A detailed discussion of this disease is to be found in New York (Cornell) Agricultural Experiment Station Bulletin 363. Recent work indicates that a root rot resembling the Phytophthora root-rot is caused by a species of Fusarium or Ramularia. Roots attacked by the latter are softer and are always accompanied in the last stages by a strong odor.

and Phytophthora soft-rot, affects the leaves, stems, and roots of plants of all ages and is very widespread. In some sections

FIG. 6.—Sprayed and unsprayed ginseng plants attacked by Alternaria blight. Aside from spraying, both beds received the same treatment.

FIG. 7.—Ginseng plant, showing characteristic symptoms of Phytophthora mildew.

it kills from 20 to 30 per cent of the plants.

Symptoms and cause.—The leaflets at the tops of affected plants often droop at the tip or base of the petiole (fig. 7) in much the same way as those affected with Alternaria blight, and the stems after a time become hollow and somewhat discolored. The leaf blades also show characteristic spots of varying sizes, these in the early stages being much like those caused by Alternaria blight. A week or two after the spots appear the centers become white, but the margins remain a dark water-soaked green (fig. 8) and never show the yellow-brown margins which characterize the Alternaria spots. The roots, which may also be attacked, show a semisoft rot (fig. 9) and in a short time become entirely involved. If such roots are allowed to remain in the soil for any considerable length of time various organisms, such as Fusaria and bacteria, enter the diseased tissues and cause them to become soft, and

at this stage the disease is often accompanied by the disagreeable odor characteristic of vegetable decay.

The disease is caused by a fungus[1] which is closely related to that causing the late-blight of potatoes, and in many respects this disease resembles the latter. The fungus produces two kinds of spores; that is, thin-walled summer spores on the surface of the diseased parts, which serve to spread the disease during the growing season, and thick-walled winter spores in the tissues of the plants, which help to carry the fungus through the winter. The latter, which seem to be favored by an abundance of moisture, germinate in the spring, and during favorable periods throughout the growing season produce summer spores. These spores are in turn carried by the wind to the tops of healthy plants and by soil water to the roots. Infection in the spring may start either in the root and spread upward or in the stem and spread downward to the root, but in either case both root and top may become diseased.

FIG. 8.—Leaf-spot of Phytophthora mildew on ginseng.

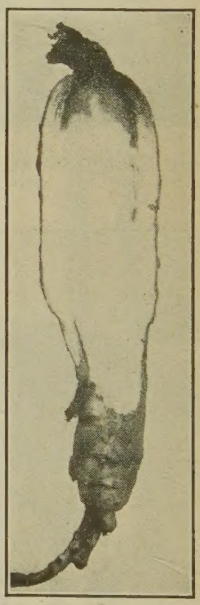

FIG. 9.—Root-rot of ginseng caused by Phytophthora mildew.

[1] *Phytophthora cactorum* (Con. and Leb.) Schröter.

Control.—Since the summer spores are produced very early in the spring, the tops of the plants should be protected against infection. This can be done by spraying with Bordeaux mixture (3–3–50), as in the case of Alternaria blight. To prevent the disease from extending down the stem into the roots, the tops of plants showing wilting or drooping should be removed by cutting them off at the crown. If the root is affected it should be carefully removed from the bed and destroyed, and the soil in which it grew should be disinfected with formaldehyde, 1 part to 50 parts of water, or with copper sulphate, 1 pound to 5 gallons of water, these to be applied at the rate of about 1 gallon per square foot of soil. As

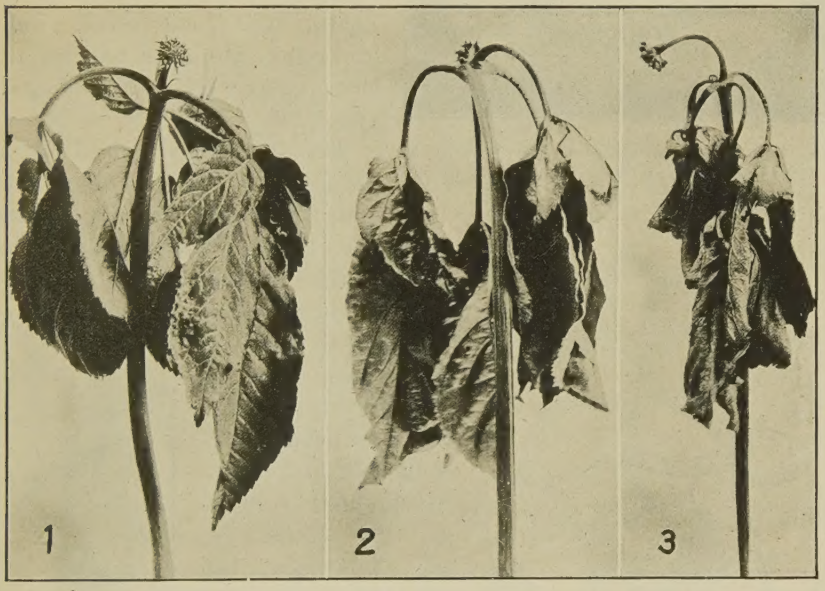

FIG. 10.—Ginseng plants, showing Acrostalagmus wilt in various stages: (1) Earliest stage; (2) a week or ten days later; (3) last stage.

abundant moisture favors the development of the winter spores, it is a good practice to tile-drain the land before making up the ginseng beds.

A garden once infected should not be used for a number of years, as it has been found that the winter spores can live in the soil at least four years. Where for some reason it is desirable to use infected land, it should be disinfected with either steam or formaldehyde (pp. 20–21), both of which have given good results.

ACROSTALAGMUS WILT.

Acrostalagmus wilt is a disease of the older ginseng plants. During the past two years reports of its occurrence have been fewer

than previously. The loss which it causes seldom exceeds 5 to 10 per cent of the crop.

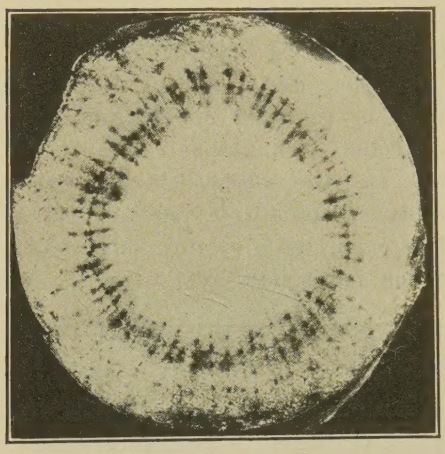

FIG. 11.—Section of a ginseng root, showing a discolored ring of water-conducting tubes, due to Acrostalagmus wilt.

Symptoms and cause.—Although this is a root disease, the first symptoms appear in the tops, which gradually wilt. Affected plants are scattered here and there in the bed. At first, the leaves become flagged, and gradually the entire top wilts and dies (fig. 10). Externally the roots appear to be healthy, but if cut across, a yellow zone, extending part or all the way around, will be found (fig. 11).

The disease is caused by a fungus[1] which produces minute spores on the roots. The spores live in the soil and serve to spread the pathogene to healthy roots. These spores give rise to the root-like threads of the fungus, which penetrate the healthy ginseng root and establish themselves in the sap-tube region (fig. 12). They injure the sap tubes, causing the yellow zone above described and bringing about the wilting of the tops.

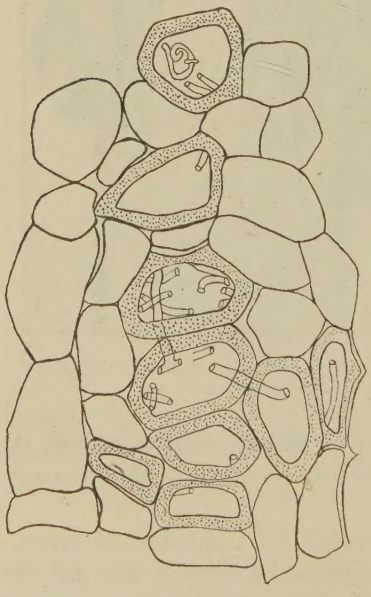

FIG. 12.—Section through a ginseng root, showing water-conducting vessels filled with threads of the fungus causing the wilt. (After Van Hook.)

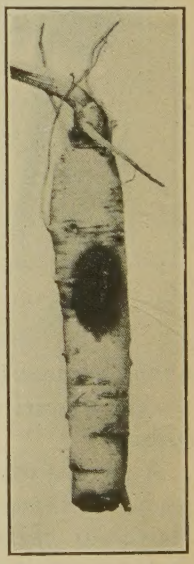

FIG. 13.—Thielavia rot on an older ginseng root.

Control.—As the older roots only are affected, they should be dug and dried, so as to remove the source of infection, and the soil in which a diseased crop has been grown should be disinfected by the use of either formaldehyde or steam.

[1] *Acrostalagmus* sp.

THIELAVIA ROOT-ROT.

The Thielavia root-rot affects plants of all ages, but is most common in the seedling beds, many of which are often rendered worthless. Specimens showing this disease have been collected from 11 States.

Symptoms and cause.—The rotting may occur on any portion of the roots of older plants. The spots have a grayish black appearance, but do not penetrate deep into the root (fig. 13). In the case of seedlings the end of the taproot and the fibers are attacked, root hairs and many of the smaller rootlets are lacking, and instead of being long the taproot frequently becomes knoblike (fig. 14).

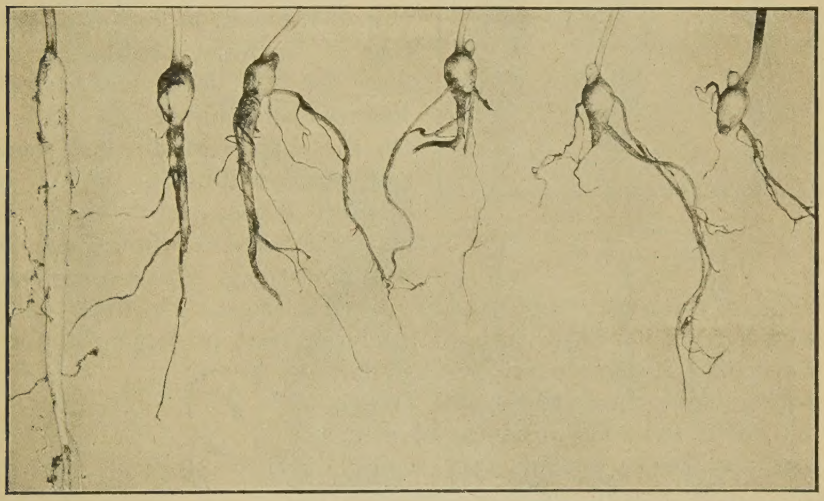

FIG. 14.—Roots of seedling ginseng plants, showing the effect of Thielavia rot.

The disease is caused by a fungus,[1] and its ability to attack plants is favored by an alkaline condition of the soil.

Control.—Where ginseng is found in the natural forest the soil is acid, and since alkaline soil favors the development of the disease, the grower should try to have the soil of the ginseng garden of an acid reaction. This can be done by applying acid phosphate at the rate of 1,000 to 2,000 pounds per acre, the amount depending on the previous treatment of the beds and the alkaline condition of the soil. It is likewise obvious that lime, ashes, or other alkaline fertilizers should not be applied to ginseng beds. Before being sown to seed, infected beds should be treated with steam or formaldehyde.

[1] *Thielavia basicola* (B. and Br.) Zopf.

SCLEROTINIA WHITE-ROT.

Sclerotinia white-rot occurs in most ginseng-growing regions, but has never been known to be epidemic in the ginseng garden. It also affects lettuce, beets, tobacco, cucumbers, and many other cultivated plants, and this probably explains its distribution in ginseng gardens, in many of which some of these crops were previously grown.

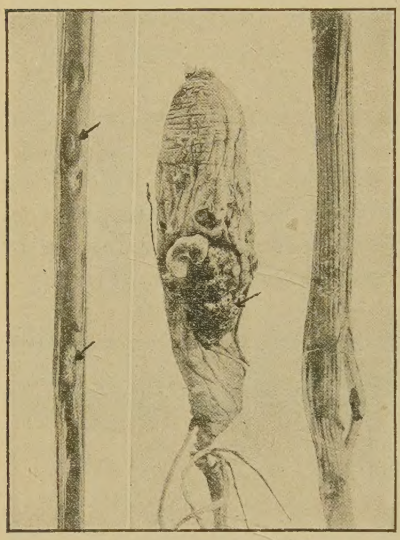

FIG. 15.—Sclerotinia white-rot on ginseng root and stems.

Symptoms and cause.—The disease may affect the stem and root (fig. 15), but in no case is a spotting of the foliage known. Soon after the stem is affected it loses its green color and becomes hollow. On the outside of diseased roots, and often within the hollow of diseased stems, are to be found hard black bodies, often a quarter of an inch long. These are resting bodies of the causal fungus and are called sclerotia. The disease may start at any point in the root and gradually work its way up through the stem, or it may start in the stem and work downward toward the root. When the soil is wet after a continued rainy spell the disease spreads very rapidly, entire roots sometimes rotting completely in five days. The tissue of diseased roots becomes soft, cheesy, and brittle, but has no bad odor.

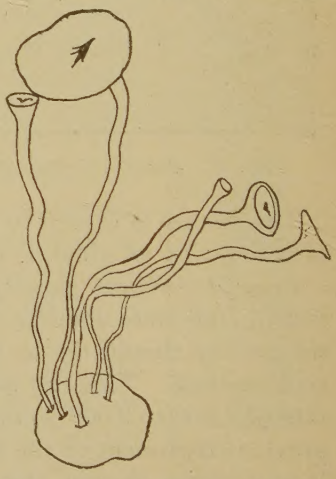

FIG. 16. — Sclerotinia white-rot, showing cup-shaped bodies which arise from the sclerotia of the fungus.

The disease is caused by a fungus[1] which is characterized by its hard, black sclerotia, or resting bodies, varying in size from a pinhead to half an inch in length. The sclerotia remain in the soil or in the dead tissue during the winter, and in the spring produce small, cuplike structures (fig. 16), which contain numerous spores. These spores are carried by the wind to the stems, where they germinate and send rootlike threads into the tissues. The roots

[1] *Sclerotinia libertiana* Fckl.

may be infected by the threadlike growth of the fungus from the sclerotia, especially where there is an abundant supply of moisture.

Control.—Good drainage and aeration are so closely connected with the growth of the fungus that they are the prime factors to be considered in connection with the control of the disease. The diseased tops and roots should be removed and the soil from which the latter were taken should be disinfected with a solution of formaldehyde, 1 part to 50 parts water, or with copper sulphate, 1 pound to 10 gallons of water. This will tend to prevent the formation of the sclerotia in the soil.

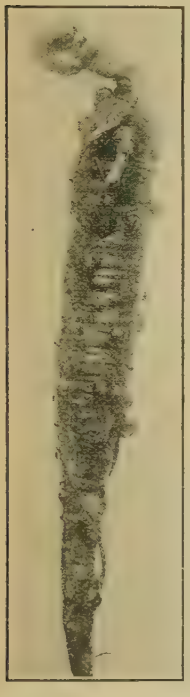

FIG. 17.—Sclerotinia black-rot, showing ginseng root and bud affected the first year. The surface is black, but the root is plump and firm.

SCLEROTINIA BLACK-ROT.

Sclerotinia black-rot was doubtless originally a disease of wild ginseng. It also affects another common forest plant known as false Solomon's-seal,[1] and without question is often introduced into ginseng gardens through the forest soil used by many growers in making up their ginseng beds.

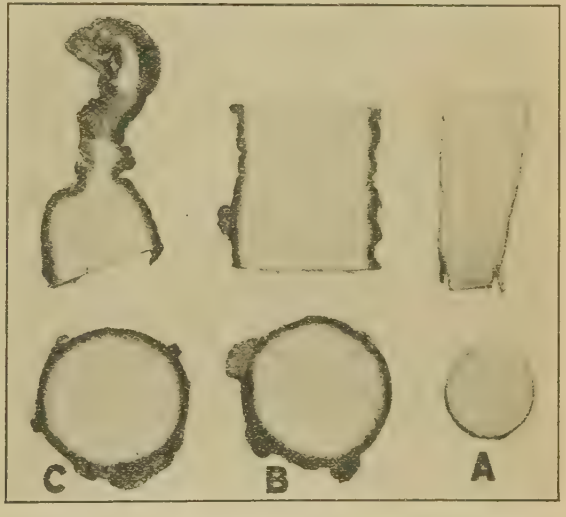

FIG. 18.—Sclerotinia black-rot of ginseng. Sections through root and bud, showing coal-black margins the first year. *A*, A healthy root; *B* and *C*, diseased.

Symptoms and cause.—This disease affects the roots only and is distinctly a winter disease in that it makes no progress during the growing season. The most striking sign of the presence of this disease in a garden is the failure of plants to come up in certain spots or areas in the beds. On digging into such spots the black mummy-like roots will all be found in place. Frequently two winters pass

[1] *Smilacina racemosa.*

before the root is finally destroyed. During the first season after the root is affected it remains plump and firm, but the outer surface becomes coal black (fig. 17), while during the second year it becomes black throughout, shrinks, and finally decays. A section through an affected root during the first year will show the coal-black outer rind (fig. 18).

FIG. 19.—Sclerotinia black-rot, showing cuplike bodies formed the second season on an affected ginseng root.

This disease is caused by a soil fungus.[1]

In the autumn, small black enlargements, sclerotia (fig. 19), are formed, and these produce mycelia or threadlike growths on the outer tissues of the root, which grow through the soil and infect surrounding healthy plants. Cuplike bodies (fig. 19) are also produced, and these bear spores which are washed into the soil by rains and infect the healthy roots.

Control.—All the black roots in a diseased area should be removed and destroyed and the soil thoroughly disinfected with a solution of formaldehyde, 1 part to 50 parts water.

DAMPING-OFF OF SEEDLINGS.

Damping-off is the name applied to some diseases of seedlings caused by certain organisms that live in the soil and are especially favored by excessive moisture and lack of aeration.

Symptoms and cause.—The stems of affected plants become soft and rot at the surface of the soil and the tops drop over (fig. 20). The common damping-off fungus[2] and the "sterile" fungus Rhizoctonia have been found associated with these diseases, and occasionally the mildew fungus[3] produces the effects described.

FIG. 20.—Ginseng seedlings affected with damping-off. Note the sharp angle where they bend over. (After Van Hook.)

[1] *Sclerotinia smilacina* Dur.=*S. panacis* Rankin.
[2] *Pythium debaryanum* Hesse.
[3] *Phytophthora cactorum* (Con. and Leb.) Schröter.

Control.—Good drainage and aeration are of the greatest importance in raising seedlings; consequently, tile drainage is recommended. Damping-off caused by Rhizoctonia has been checked by sprinkling clean sand on the surface of the bed to a depth of one-fourth to one-eighth of an inch. Where the garden is small and it is

FIG. 21.—Adjacent ginseng seedling beds, showing the effect of formaldehyde treatment: *A*, Not treated; *B*, treated with formaldehyde solution before planting.

possible to do so, it is well to sprinkle it with sand several times during the growing season. When the seedlings are planted in drills the loosening of the soil after rains is very helpful. Before seed is planted in beds in which ginseng has been grown the soil should be

disinfected with a solution of formaldehyde, 1 part to 50 parts water. This should be done a week or ten days prior to planting, according to the specific directions given on page 21. Excellent results have been obtained by such disinfection (fig. 21, *A* and *B*). When damping-off spots appear in a bed of seedlings its spread may be checked by drenching the infected portions of the bed with a solution of formaldehyde, 1 part to 100 parts of water. Steaming is also very effective.

PAPERY LEAF-SPOT.

Papery leaf-spot is common during dry seasons. It is not of a parasitic nature, and consequently never spreads from plant to plant. Usually only a few plants in certain places in the garden show the trouble.

FIG. 22.—Leaves of ginseng affected with papery leaf-spot.

Symptoms and cause.—The disease is characterized by the spotting of the leaves (fig. 22), the spots appearing between the veins or along the margins. The spots are transparent, often have a yellowish tint, vary from small and circular to large and oblong or irregular, and are of a papery texture, the last portion to become affected being the large veins and the midrib. The spots produced by this disease differ from other spots in that they are more transparent when examined against the light.

The trouble is caused by an insufficient supply of water, and this may be brought about by various causes, such as lack of rainfall and consequent lack of moisture for the plants; large roots of trees within the beds, which exhaust the water supply; insufficient shade and consequent rapid drying out of the moisture; excessive use of nitrate of soda; and, as a result of fungi or unfavorable conditions, a lack of fine root hairs to take up the moisture from the soil. Under the conditions last mentioned the papery leaf-spot may occur in beds which have a sufficient supply of moisture.

Control.—The only remedy that can be suggested, as indicated by the foregoing, is the correction of unfavorable conditions. To this end tile drainage should be used, as it equalizes the moisture and protects the plants in dry seasons. Beds should not be made near large trees, and the plants should be kept in a healthy condition in order that they may have a large number of feeding roots for the absorption of water.

SPRAY INJURY.

Spray injury results from the use of spray mixtures, as the term indicates. Injury from spraying is seldom very severe, but attention is called to it so that it may not be mistaken for a disease.

Symptoms and cause.—The symptoms of spray injury depend on the mixture or solution used. Those which have heretofore caused injury are Bordeaux mixture and lime-sulphur. When an application of the former is followed immediately by cold weather it will often cause a browning and then a shriveling of the edges of the leaves, or even the death of the tender young tops and stems, and on the older leaves small, circular brownish spots. When applied in early spring lime-sulphur causes a stunting of the entire plant, while the edges of the leaves may also show symptoms similar to those caused by Bordeaux mixture.

The foliage of ginseng seems to be particularly subject to injury from lime-sulphur, but the reason for this is unknown. In the case of Bordeaux mixture the cause of injury is improper preparation, too small a supply of lime in the mixture being the usual source of the trouble.

Control.—Lime-sulphur should not be used for spraying ginseng, and in preparing Bordeaux mixture care should be taken to use a high grade of lime and enough lime milk (not the clear lime water) to combine with all the soluble copper. (See p. 19.)

RUST.

Symptoms and cause.—Rust attacks the roots, causing them to appear rusty or copper colored, but never attacks the tops. The disease occurs on plants of all ages, but affected plants usually reach maturity.

All efforts to find a definite organism associated with the disease have failed. Doubtless several of the root rots (especially those caused by *Alternaria panax* and *Thielavia basicola*) are commonly included, with other brown rots and rusty discolorations of the roots, under this name "rust."

Control.—No satisfactory way of controlling rust has been worked out, but one of the writers obtained good results from sterilizing the soil with steam.

NEMATODE ROOT-GALL.

The nematode gall is a root trouble, but in rare instances the stems also show the galls. The disease has been reported from all the ginseng-growing sections.

Symptoms and cause.—The severity of the disease may vary, but the grower should have no trouble in recognizing it by the nodules or swellings found on the fibers and smaller rootlets (fig. 23) and sometimes on the main root. After a time these swellings, or galls, as they are sometimes called, turn brown, become water-soaked, and finally decay.

FIG. 23.—Ginseng roots, showing nematode galls.

This disease is caused not by a fungus, but by a minute parasitic eelworm,[1] which also causes root galls on many common weeds and cultivated plants. This parasite lives in the soil, where it comes in contact with and penetrates the tender tissues of the root, and by stimulating the root tissues produces the galls. It lays its eggs within the tissues of the root or in the soil, and here they hatch and produce another generation of worms. A number of generations may be produced in a single summer. The worms pass the winter as larvæ, either in the soil or in the root.

Control.—It has been suggested that a rotation with goldenseal would rid the soil of nematodes, but the work of one of the writers has shown that this plant also is attacked by the parasite. In view of this fact, the only remedy that can be suggested here is the sterili-

[1] *Heterodera radicicola* (Greef) Müller.

zation of the soil with steam. Soil treatment with formaldehyde has not proved effective. To prevent the infection of healthy roots care should be taken to avoid the transfer of infested soil or diseased roots from one bed to another. As the worms are usually brought into clean gardens in the roots of nursery stock, great care should be taken in selecting healthy roots.

FIG. 24.—Ginseng bed, showing plants killed by lightning around a post which also was damaged.

LIGHTNING INJURY.

Recently one of the writers observed a striking case of injury from lightning in a ginseng garden in Wisconsin (fig. 24). All the plants in a circular area a rod in diameter were killed or injured, the tops turning brown, wilting, and dying. In many cases the fibrous roots were completely stripped from the main root. Only 10 per cent of the roots developed tops the following season, and these appeared to be weak and sickly. However, injury to ginseng from lightning seems to be rare, the dying of plants in circular areas in the beds being due usually to some fungous disease.

RELATION OF FERTILIZERS TO DISEASE.

Lime and wood ashes.—From the natural acid character of the forest soil it would appear that lime or wood ashes are of doubtful value to ginseng grown under cultivation. It was found that wherever lime was used, especially on seedling beds, injury followed. This was due to the fact that an alkaline soil favors the development of the Thielavia fungus, and in view of this the use of lime or ashes on ginseng beds should be avoided.

FIG. 25.—Ginseng leaves showing injury caused by an excess of nitrogenous fertilizers.

Acid phosphate.—The effect of acid phosphate is entirely opposite to that of lime. Many growers make a practice of applying acid phosphate each fall before putting on the mulch. From 1,000 to 2,000 pounds per acre have given good results, but the quantity that should be applied varies according to the condition of the soil.

Nitrogenous fertilizers.—Fertilizers containing nitrogen are of value when not used to excess. A heavy application of nitrate of soda or of barnyard manure may cause injury to the leaf (fig. 25).

SPRAYING.

Spraying is the application of substances in water to the surface of the plant to protect it from the attacks of parasitic fungi or insects. It is not a cure, nor can it be used to protect the portions of the plant below the surface of the ground.

Bordeaux mixture.—Bordeaux mixture, either homemade or commercial, has been found to be the most reliable spray for ginseng. The homemade Bordeaux mixture is made of copper sulphate (blue vitriol) and good hydrated or stone lime. The strength recommended for use in spraying ginseng is 3-3-50; that is, 3 pounds of copper sulphate, 3 pounds of stone lime, and 50 gallons of water. To prepare such a solution, dissolve 6 pounds of copper sulphate in 50 gallons of water by suspending the crystals in a sack just beneath the surface of the water, slake 6 pounds of stone lime with hot water, and when completely slaked add enough water to make 50 gallons of lime milk. When ready to spray, mix equal parts of the two solutions, taking care to stir both. Never pour the two solutions together until ready to apply. To remove particles that might clog the nozzle, it is well to strain the mixture as it goes into the sprayer. An insecticide, such as arsenate of lead, 2 pounds to 50 gallons of Bordeaux mixture, may be added to this mixture.

Before applying Bordeaux mixture it is absolutely necessary to use lime enough to act on all the blue vitriol. This may be determined by what is known as the ferrocyanid test. An ounce of the yellow prussiate of potash is dissolved in a pint of water. When placed in a bottle this will keep indefinitely. Lime should be added to the copper-sulphate solution until the prussiate of potash will not turn brown when dropped from the bottle into the mixture. Then add an extra gallon or so of the lime milk. A slight excess of the lime will do no harm and will insure against spray injury from free copper.

Spraying should be begun as soon as the plants come up, but applications just before freezing should be avoided. The frequency of applications depends on the growth of the plants and on the disease for which they are being sprayed. All growing parts of the plant as they become exposed should be covered with the spray. The spray should be applied just preceding rains, as the fungus spores germinate and infect the plants during rains. The plants should not be sprayed when in blossom, as spraying has a tendency to prevent the setting of the berries. Leaves, stems, and seed heads should be completely covered on all sides with the spray. Thorough work can best be done with a nozzle which gives a fine mist and with a pressure of not less than 50 pounds, or, better, 100 to 150 pounds.

Lime-sulphur.—Little success has followed the use of lime-sulphur for ginseng diseases. If used at all, it should not be applied during the early stages of the growth of the plants.

SOIL DISINFECTION.

Because of the fact that the disease-producing organisms gradually accumulate in the soil, diseases are more prevalent in soils on which ginseng has previously been grown. Before using a soil in which this crop has been grown it should be sterilized with steam

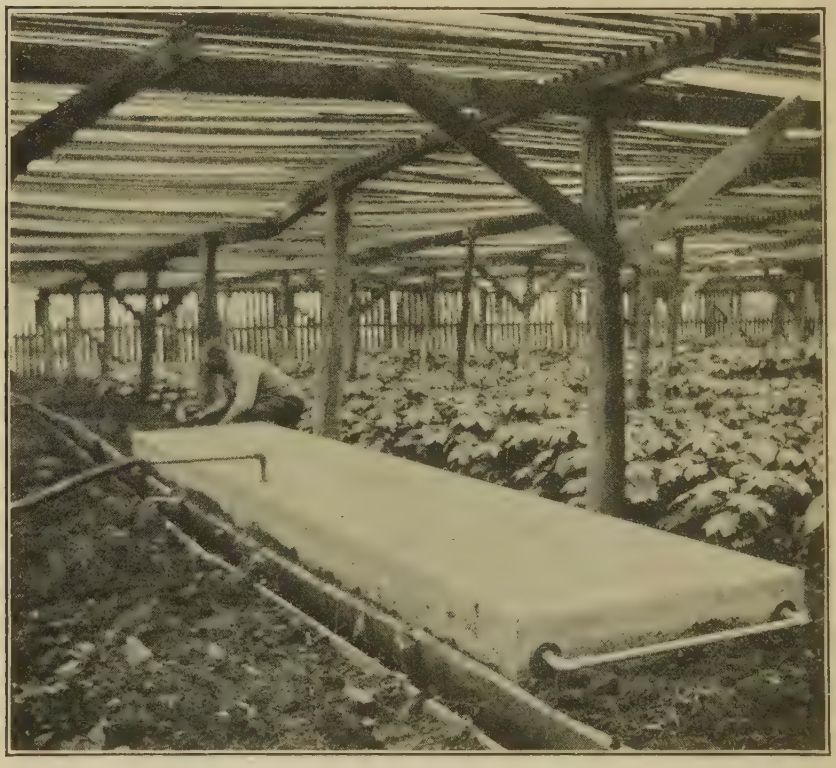

FIG. 26.—Inverted pan for sterilizing the soil with steam.

or disinfected with formaldehyde, so as to destroy as many of the disease organisms as possible.

Steam sterilization.—The steaming should be done very early in the spring or in the fall. In addition to killing the fungi it also kills to a large extent the weed seeds. The labor of weeding thus saved is enough to pay for the cost of treatment. It also changes the physical texture of the soil, making it more suitable for root development, and considerable plant food is made directly available

to the plant. As stated in Bulletin No. 250 of the Bureau of Plant Industry, the inverted-pan method (fig. 26) devised by Mr. A. D. Shamel, of this bureau,[1] appears to be the most practicable for ginseng beds. "The apparatus for ginseng beds of the usual width should consist of a galvanized-iron pan, 4 by 10 feet and 6 inches deep, which is inverted over the soil to be sterilized, the steam being admitted through a steam hose connection in the end or side of the pan. The sharp edges of the pan which are forced down into the soil prevent the escape of the steam. The pan is fitted with handles for moving and should weigh not more than 400 pounds. The soil is prepared as for planting. All fertilizers are applied and worked in as desired. A few potatoes are buried at a depth of about a foot, to gauge the degree of heat attained. These should be cooked when sterilization is completed. The steam should be kept at as high a pressure as possible, 80 to 100 pounds." The treatment should be continued for 20 minutes to 1 hour, depending on the pressure of the steam and the character of the soil.

Formaldehyde disinfection.—Formaldehyde has been used again and again by various growers with very good results (see fig. 21). The treatment should be undertaken in the autumn, but in some cases it may be given in the spring. All the roots should be removed from the beds and the soil thoroughly worked up. The formaldehyde (40 per cent solution) is diluted and is applied by one man with a hose or a large watering pot, while another man spades over the soil. The soil should be as dry as possible, but if wet the proportion of water should be reduced accordingly. The grower should first test how much water each square foot of soil will hold, and then dilute the formaldehyde so that 1 gallon of the strong or 40 per cent solution will be distributed over 50 square feet of soil. The soil should not be worked after treatment until the excess of water is well drained off. As soon as it will work without puddling it should be again thrown up loosely, to permit the evaporation of the formaldehyde. Ten days to two weeks after treatment, several respadings having been made, the beds should be in condition for planting.

DRAINAGE OF GINSENG BEDS.[2]

Artificial drainage is a necessity in the ginseng bed, not only from the standpoint of culture, but also as regards diseases, which, as has been shown, are favored by excess of water in the soil. In the re-

[1] One of the writers has added an attachment to the steam-inlet tube in the form of a wing steam distributor, and by means of this device there is a uniform distribution of the steam to all parts of the pan.

[2] For detailed information regarding tile drainage, see Farmers' Bulletin 524, United States Department of Agriculture.

moval of such water good results have been obtained from the use of draintile in the ginseng bed. It is impossible to give definite directions for a system of drainage, as the amount necessary varies with the character of the soil and the rainfall. Generally speaking, 3-inch tiles should be placed 6 to 8 feet apart and 3 to 4 feet deep in sand and gravel and 1½ to 2 feet deep in clay.

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WASHINGTON: GOVERNMENT PRINTING OFFICE: 1916